



US Army Corps
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Waterways Experiment
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Zebra Mussel Research

Technical Notes

Section 2 — Control Methods

Technical Note ZMR-2-20

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Effects of Forced Hot Air on Zebra Mussel (*Dreissena polymorpha*) Mortality

Background and purpose

It has been over a decade since zebra mussels (*Dreissena polymorpha*) were first found in benthic samples from Lake St. Clair, Michigan (Herbert, Muncaster, and Mackie 1989). Although chlorine and other chemicals are being used for their control at hydropower stations and other facilities (Miller, Payne, and McMahon 1991; Claudi and Mackie 1994), managers and government officials are encouraging use of alternative, nonchemical methods. Experiments conducted by McMahon, Ussery, and Clarke (1993) were designed to obtain information on the efficacy of dewatering mussel-infested structures. For example, mussels experienced 100 percent mortality when exposed to still air at 25 °C and 95 percent relative humidity for 96 hr. Ricciardi, Serrouya, and Whoriskey (1995) reported similar results at 50 percent relative humidity and temperatures of 20 and 30 °C.

Jenner and Janssen-Mommen (1992) suggested that forcing hot air through dewatered pipes, rather than just exposing them to the atmosphere, should increase mussel mortality. This could greatly reduce the amount of nonoperational time required to kill zebra mussels at a hydropower plant, navigation lock, or other facility.

This technical note reports the results of a laboratory experiment on the use of forced hot air to kill zebra mussels.

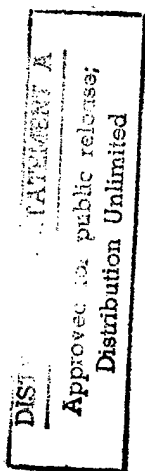
Additional information

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Approach

Zebra mussels were allowed to naturally colonize 7.62-cm-wide by 61-cm-long polyvinyl chloride (PVC) pipes attached to a concrete wall at Black Rock Navigation Lock during the summer and fall of 1994. Pipes were removed on 31 November 1994, packed in coolers with artificial coolant, and shipped to the



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laboratory at the U.S. Army Engineer Waterways Experiment Station in Vicksburg, MS. For each experiment, an infested pipe was attached to a 2-m length of clean pipe that was connected to a standard floor heater with temperature maintained by a Dyna-Sense proportional AC phase controller. A small fan was placed into a PVC pipe coupler near the floor heater. Air speed was measured with a hand-held wind speed indicator (Davis Instruments), and relative humidity and temperature with a Cole-Parmer 3309-60 thermo-hygrometer and Fisher Scientific 15-077-11 digital thermometer.

Two trials were conducted at each of three temperatures (25, 35, and 45 °C). During each trial, six individuals were removed periodically and tested for viability by re-immersing them in dechlorinated tap water for 12 hr at room temperature (22 to 24 °C) and then gently probing the exposed mantle edge with a small brush. The mussel was considered viable if it closed its valves in response to this stimulation. Exposure durations were designed to include 100 percent survival to 100 percent mortality (SM_{100}). Because there were no significant mortality differences between trials for each treatment (Student's *t*-test), all data from each temperature were fitted to an equation using least squares linear regression analysis to estimate time for 50 percent mortality (LT_{50}).

Forced air speed was maintained at 1.8 m/sec for all treatments. Average relative humidity varied from 46.1 percent at 25 °C to 39.3 percent at 45 °C. Air temperature exiting the test apparatus was always within 2 °C of that entering it.

Results and discussion

Equations from regression analysis for each experimental temperature were significant ($p < 0.05$), enabling predictions of LT_{50} (Table 1). At a test temperature of 25 °C, LT_{50} using forced air was approximately 10 hr less than with still air, based on studies by McMahon, Ussery, and Clarke (1993). At 35 °C, the LT_{50} was approximately one third the value obtained by McMahon for still air. Results were the same for all sizes of mussels tested.

Table 1. Estimated LT_{50} for Effects of Still Air (Taken from McMahon, Ussery, and Clarke 1993) and Effects of Forced Air on Zebra Mussel Mortality (Present Study)					
Temperature °C	Still Air LT_{50}	Forced Air			
		SM_{100}	R^2	P	LT_{50}
25	43	49.0	0.79	<0.00001	32.7
35	16	11.0	0.66	<0.00131	4.6
45	Not determined	2.5	0.95	<0.00408	1.4

Studies by McMahon, Ussery, and Clarke (1993) and Ricciardi, Serrouya, and Whoriskey (1995) demonstrated that exposing components of facilities to warm still air would be an efficient and cost-effective way to control zebra mussel infestations. As suggested by Jenner and Janssen-Mommen (1992) and Claudi and Mackie (1994), the present study indicated that forced hot air could greatly reduce the amount of nonoperational time required to mitigate zebra mussel infestations. Alternatively, individual components could be dewatered and treated separately. Hot air is easily and inexpensively generated, and the associated environmental impacts from discharge are usually negligible.

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